

STUDIES ON OLIVIDAE. III.

NOTES ON *OLIVA BULOWI* Sowerby, 1888.

DESCRIPTION OF A NOVEL SUBSPECIES

OLIVA BULOWI PHUKETENSIS.

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ABSTRACT. A novel subspecies *Oliva bulowi phuketensis* so far known from South-West Thailand and Andaman Islands, is described. Problems of allometry and colour pattern dimorphism in juvenile *Oliva bulowi* are discussed.

RESUME. Une nouvelle sous-espèce *Oliva bulowi phuketensis*, connue jusqu'ici du Sud-Ouest de la Thaïlande et des îles Andaman, est décrite. Des problèmes d'allométrie et de dimorphisme du motif coloré des juvéniles d'*Oliva bulowi* sont discutés.

KEYWORDS. Mollusca, Gastropoda, Olividae, *Oliva bulowi phuketensis*.

1. INTRODUCTION.

Oliva bulowi was described by Sowerby in 1888. The original description is given in section 4.1. The date of publication and the spelling are discussed by WALLS and WALLS (1976). This species is not rare but as it is generally collected by scuba diving or by dredging it is poorly represented in most collections. The geographical distribution of this mollusk is discontinuous. Most specimens come from Papua New Guinea (specially New Britain) and Solomon Islands. Specimens of a rather different aspect have been repeatedly obtained from shell dealers in Phuket (Thailand) and are said to be obtained by local divers in rather deep water. Very similar specimens occur in the Andaman Islands (Winckworth collection, BMNH). The shell is said to occur in the Philippines but we have not seen any undoubted Filipino specimen in any of the local collections we have examined. As far as we know it has not been collected in Indonesia. As its colour pattern is mostly very characteristic, *Oliva bulowi* is generally thought to be a "no-problem" oliva, one of the few unmistakable species in the genus.

This assumption was challenged when some years ago one of us (D.G.) had his attention attracted upon some enigmatic *Oliva* collected by scuba diving at Lion Island, near Port Moresby, Papua New Guinea. Although obviously related to *Oliva bulowi* these "X" shells had a more slender shape and a very different colour pattern, somewhat reminiscent of certain specimens of *O. semmelinki* Schepman, 1911. Typical *O. bulowi* have a "tiger" pattern (see pl. 1, 11-20) while the "X" shells

have a "panther" pattern (see Pl. 1, 6 to 10). Several "X" shells have also been collected by one of us (B.T.) from the waters around Laing Island Biological Station, on the North coast of Papua New Guinea. "X" shells are apparently easily separated on simple visual inspection. Should they be separated by stable discriminants, the "X" shells would constitute a full, separate species as they are strictly sympatric with the typical form.

This situation required a re-examination of the homogeneity of *O.bulowi*. In addition, the present paper also aims at pointing at some of the difficulties encountered in the interpretation of data.

2. METHODS.

2.1. The methods and the measurements utilized here are described in detail by TURSCH and GERMAIN, 1986a and 1986b. As a quick reminder they are sketched in fig.1. *nw* and *pnw* are respectively the number of nuclear whorls and the number of post-nuclear whorls. In order not to start by introducing a *a priori* taxonomic assignments, the detailed list of the material examined has been placed at the end of this paper, in section 7.

2.2. this study started with forming several lots by a simple visual inspection of the intact shells at hand:

1. adult shells from the Andaman Islands (9 specimens).
2. adult shells from Phuket, Thailand (8 specimens).
3. adult typical shells from Port Moresby (5 specimens).
4. adult typical shells from New Britain (10 specimens).
5. adult typical shells from Laing Island (10 specimens).
6. adult typical shells from the Solomons (10 specimens).
7. "X" shells from Port Moresby (8 specimens).
8. "X" shells from Laing Island (8 specimens).

2.3. Potential discriminants (taxonomic characters) were then found by a computer-assisted program comparing the overlap of the distribution (actually this was done by calculating the overlap of the 95% probability ranges) of every group of shells with every other group for a large series of measurements and measurements ratios yielding at least one overlap of less than 65% (an arbitrary decision) were considered as potential characters. Thirty such discriminants were found: H, H/L, D/L, X/L, (H-L)/L, *nw*, MPRO, RES4, RES5, RES7, RES4/RES5, H/*pnw*, LW/*pnw*, D/*pnw*, X/*pnw*, R/*pnw*, (H-L)/*pnw*, (LW-L)/*pnw*, L/*pnw*, (logD)/(logL), (logX)/(logL), (logR)/(logL), (log(H-L))/(logL), (log(LW-L))/(logL), (logSUT)/(logL), (logX)/*pnw*, (logR)/*pnw*, (log(H-L))/*pnw*, (log(LW-L))/*pnw* and (logSUT)/*pnw*. Their list will be called list A.

3. OBSERVATIONS AND RESULTS.

3.1. UPGMA.

An euclidian distance matrix was formed with 51 individual shells of the groups listed in section 2.2. on the 30 characters of list A (section 2.3.). UPGMA clustering (see SNEATH and SOKAL, 1973) led to a phenogram (not illustrated

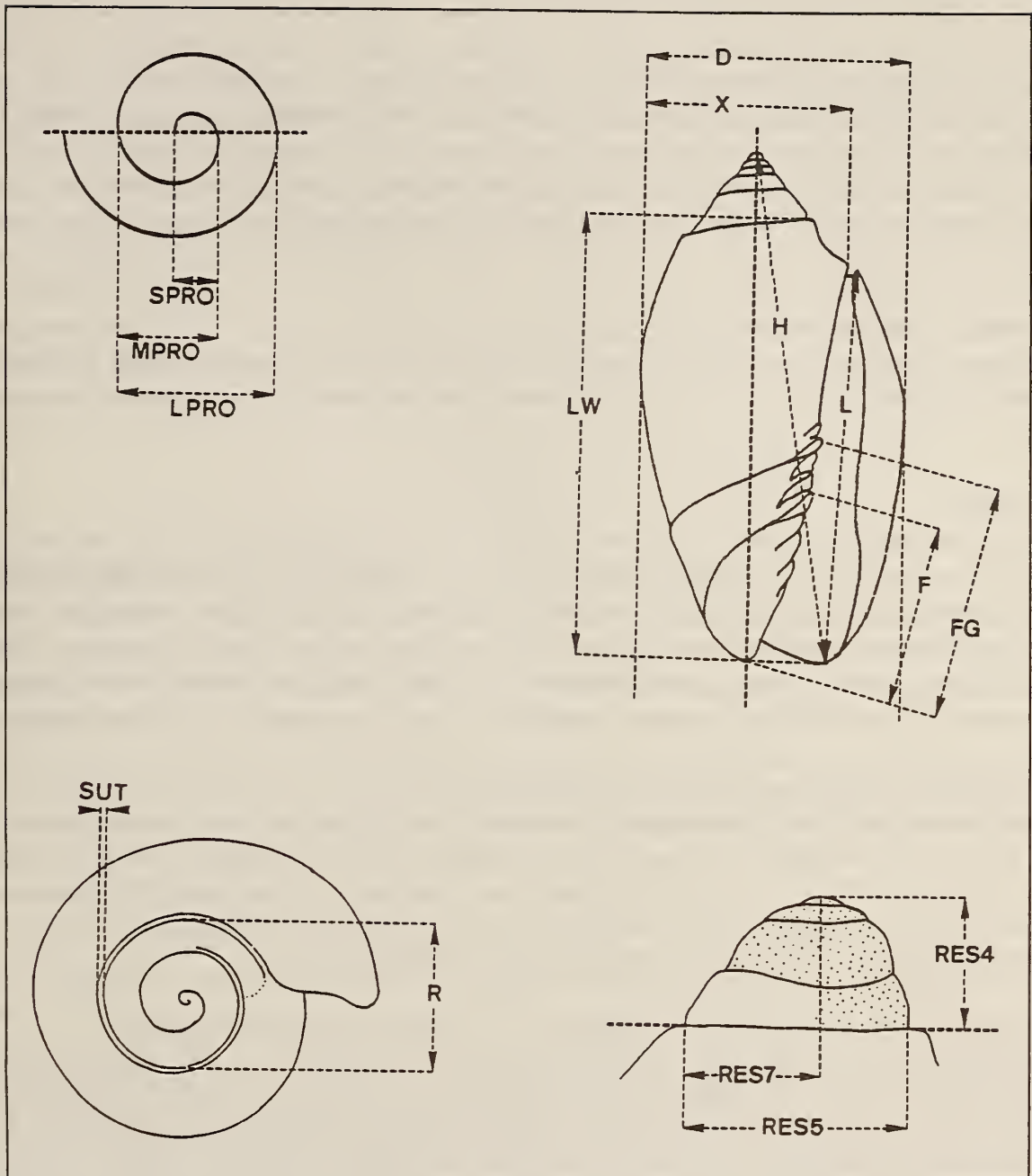


Fig. 1.
 Sketch of measurements utilized in this work. For accurate definitions, see TURSCH and GERMAIN, 1986a and 1986b.

because of its size) where three groups are clearly separated, without any intergradation. The first group include all Melanesian adult, typical shells, all clustering at a taxonomic distance of 0.29. The second group contains all the "X" shells, clustering at 0.22. The third group includes all the specimens from the Andaman Sea, clustering at 0.28. These groups appear homogeneous and indeed, in further work, we did not find any discriminants separating the various populations within the groups. The two first groups join at 0.34. The shells from Andaman Sea join all the others at 0.42.

3.2. UPGMA on centroids.

A simplified picture is obtained by considering the phenogram (Fig.2) obtained by UPGMA clustering of the euclidian distance matrix of the centroids of every population of section 2.2.

3.3. TAXSEE.

These observations were confirmed on all the individual shells of the entire sample of section 3.1. by visualization of the attribute hyperspace by the TAXSEE program (orthogonal projection of the OTU's on the plane of three centroids, see TURSCHE and GERMAIN, 1986a). The result (Fig.4) shows three clearly separate, homogeneous groups, without any intergradation. At this stage it seemed fairly certain that suitable, simple discriminants would be found to separate the three groups.

3.4. Allopatric inhomogeneity in the Andaman Sea.

Specimens from the Andaman Sea, although clearly recognizable as a form of *bulowi* have a rather different aspect. The shells are more slender, have a colour pattern very much like the "X" shells and are lighter in construction. They are separated from all other groups mainly by their protoconch characters as can be seen, for example, on a plot of RES4 vs. RES5 (see Fig. 6).

3.5. Sympatric inhomogeneity in Melanesia : "tigers" versus "panthers".

Although their protoconch characters appear identical, the "X" shells (with the "panther" pattern) are different in shape from the typical adult melanesian *bulowi* ("tiger" pattern), being more slender in outlook. This is expected to be reflected in measurements involving D, X and R. Indeed, good separations are obtained as can be seen, for instance, in the scatter diagram of $(\log X)/(\log L)$ vs. D/H (Fig. 7).

3.6. "Tigers" versus "panthers", revisited.

The fact obtained so far indicate the presence of three separable phena in the sample under study. It does not necessarily follow that these phena constitute three distinct biological entities.

The "X" shells ((with the "panther" pattern) were initially (section 2.2.) segregate from the typical melanesian *bulowi* (with the "tiger" pattern) on the sole basis of colour ornamentation. While the "X" shells always appear more "juvenile" (as their shells are smaller, with the lip not thickened and a smaller number of postnuclear whorls pnw), the initial separation seemed justified by the common occurrence of small, juvenile *bulowi* with the typical "tiger" pattern.

These typical juveniles are more slender than the adults and are devoid of the characteristic angulosity of the adult body whorl, as already noticed by HINTON (1972, p. 50). Our suspicions were aroused by the fact that the two groups are identical on all protoconch characters - a most sensitive discriminant tool in our experience - and it was decided to reinvestigate the problem, this time including typical juvenile melanesian *bulowi* in the study sample. The result is that the "X" shells can not be separated from the juvenile typical *bulowi* by any of the criteria that were tested. Intergradation is now obvious both in the revised UPGMA phenogram (Fig. 3) and in the revised TAXSEE projection (Fig. 5) as well as on all the previously effective scatter diagrams (see for instance Fig. 8).

4. CONCLUSIONS AND DISCUSSION.

4.1. The Andaman Sea specimens are separated from all others by constant differences in the protoconch. The taxonomic status of these shells can only be that of another species, a novel subspecies, or a local variant linked to typical *bulowi* by intergrading specimens along a morphocline. So far, there is no evidence whatsoever for clinal variation, as no specimen from localities between Andaman Sea and Melanesia is known to us. The decision between the status of full species and that of subspecies is always somewhat arbitrary in the case of entirely allopatric populations. We have opted for the conservative approach of considering these shells as a subspecies, *Oliva bulowi phuketensis* that will be described here below (section 5.2.). No juveniles of this shell were available for study.

4.2. The initial recognition of the "X" shells as a phenon distinct from typical adult melanesian *bulowi* is correct since the shape of juveniles is different (more slender) from that of adults that possess an angular callosity on the body whorls as already mentioned in section 3.6. To demonstrate that allometry occurs during growth one would have to establish that there is an anomaly in the variation of D or X with size. This is indeed the case as shown by the sigmoid variation curve of X vs. L (Fig. 9). This curve should be compared to a normal variation, such as, for instance, the regular variation of H with L (Fig. 10). One will notice that these graphs do not discriminate "X" shells from typical juveniles.

4.3. All the facts gathered so far concur to indicate that "X" shells are a peculiar colour form of juveniles of the typical melanesian form of *O.bulowi*. The finding of a specimen (Plate 1, figs 11 and 12) showing the "panther" pattern on the ventral face and the "tiger" pattern on the dorsal one proves that "X" shells can develop into normal *bulowi*.

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4.4. The colour dimorphism of these juvenile shells is possibly linked with depth (or more probably with the type of substrate) as the "panther" form is generally found in depths of 18 to 25 m., while the "tiger" form is usually found between 30

and 60 m. As can be seen from fig.9, the "panther" pattern of "X" shells is not found in specimens with a bulge on the body whorl, while the "tiger" pattern can be encountered in slender, juvenile shells. "X" shells have so far been found at only two localities in Papua New Guinea (Fort Moresby and Hansa Bay). One will notice that the juvenile "panther" pattern of melanesian *O.bulowi* very often persists in adults of *O.bulowi phuketensis*, a possible case of paedomorphosis (see GOULD, 1977).

4.5. This study illustrates the special usefulness of protoconch characters in the interpretation of morphometric data and also the caution that should be applied in the use of colour pattern as taxonomic characters in the genus *oliva*.

5. DESCRIPTION AND DISTRIBUTION.

5.1. *Oliva bulowi* Sowerby, 1888.

5.1.1. Original description.

"Testa subcylindraco-fusiformis, lutea, obscure griseo nebulata, antice conspicue rufo-fusco flammata; spira acuminata; anfractus 7, planato declives, griseo-fusco fasciati, sutura canaliculata sejuncti, anfractus ultimus supra medium obscure angulatus, infra medium flammis rufo-fuscis obliquis peculiariter pictus; columella rectiuscula, 7-plicata, basi contorta, albo callosa, unisulcata; aperta modica, antice paulo latior, intus albida; labrum fererectum, leviter complanatum. Long. 32, maj. diam. 13 millim. Hab. New Britain."

"This shell resembles *O. emicator* (Meusch.) in form, but the colouring is very peculiar and characteristic, with conspicuous reddish-brown flames only on the lower part of the body-whorl. The type is in the collection of Mr. Carl Bülow in Berlin, and is the largest I have seen; the smallest is about 20 millim., Pl. XXV, Fig. 3."

TYPE SPECIMENS lost during World War II.

This description, although excellent by the standards of *Oliva* literature, can be completed as follows.

5.1.2. Shell measurements and counts.

Largest specimen measured: BT-0422.

H:26.80, L:20.77, D:12.48, R:7.27, X:9.90, LW:22.72, pnw: 4.65.

Origin: Laing Isl., Papua New Guinea, dredged near Durangit Reef, in 45 m., sand.

Oliva bulowi

Protoconch data. N = 35.						
	min val.	max val.	mean val.	st. dev.	95% prob. range	% var.
nw	3.25	3.65	3.42	0.095	3.23-3.61	2.77
spro	0.13	0.22	0.17	0.017	0.14-0.21	10.05
mpro	0.32	0.42	0.36	0.022	0.31-0.40	6.12
lpro	0.57	0.68	0.62	0.029	0.56-0.67	4.64
RES4	0.81	0.97	0.89	0.079	0.95-1.27	7.12
RES5	1.42	1.69	1.53	0.063	1.41-1.66	4.11
RES7	0.78	1.02	0.92	0.055	0.81-1.03	5.94
RES4/RES5	0.52	0.68	0.58	0.036	0.51-0.65	6.16
RES4/nw	0.24	0.28	0.26	0.012	0.23-0.28	4.66
RES5/nw	0.40	0.49	0.45	0.017	0.42-0.48	3.74
lpro/nw	0.16	0.21	0.18	0.011	0.16-0.20	6.15

Oliva bulowi (adults).

Teleoconch data. N = 35.						
	min val.	max val.	mean val.	st. dev.	95 % prob. range	% var.
L/pnw	3.57	4.53	4.07	0.238	3.59-4.54	5.86
H/L	1.23	1.36	1.30	0.034	1.23-1.37	2.64
LW/L	1.07	1.17	1.12	0.022	1.07-1.16	2.01
D/L	0.59	0.69	0.65	0.023	0.60-0.70	3.60
R/L	0.34	0.40	0.37	0.017	0.33-0.40	4.73
X/L	0.48	0.56	0.52	0.021	0.48-0.56	4.01
(X-R)/L	0.13	0.18	0.15	0.012	0.13-0.18	7.75
(H-L)/L	0.23	0.36	0.30	0.034	0.23-0.37	11.47
100 (sut/L)	1.82	2.64	2.22	0.196	1.83-2.61	8.82
F/L	0.42	0.57	0.46	0.026	0.41-0.51	5.67

(values not rounded).

Note : Sowerby's specimens are much larger than those found today.

5.1.3. Colour pattern. Accurately reported in original description.

5.1.14. Distribution: Papua New Guinea, Solomons Islands.

5.2. *Oliva bulowi phuketensis* nov. subsp.

5.2.1. Measurements and counts.

Largest specimen measured: BT-1559.

H:31.50, L:22.94, D:13.90, R:8.60, X:11.20, LW:26:32, pnw:4.60.

Origin: Phuket, Thailand. Obtained by divers in deep water.

Oliva bulowi phuketensis

Protoconch data. N = 16.						
	min val.	max val.	mean val.	st. dev.	95 prob. range	% var.
nw	3.45	3.75	3.61	0.083	3.44-3.77	2.31
spro	0.16	0.21	0.19	0.012	0.16-0.21	6.25
mpro	0.35	0.41	0.38	0.015	0.35-0.42	3.99
lpro	0.62	0.69	0.66	0.020	0.62-0.70	3.07
RES4	1.01	1.25	1.11	0.079	0.95-1.27	7.12
RES5	1.64	1.90	1.76	0.079	1.60-1.92	4.49
RES7	0.96	1.17	1.07	0.063	0.94-1.19	5.87
RES4/RES5	0.55	0.69	0.63	0.041	0.55-0.71	6.53
RES4/nw	0.28	0.33	0.31	0.019	0.27-0.35	6.19
RES5/nw	0.47	0.53	0.49	0.018	0.45-0.53	3.73
lpro/nw	0.17	0.19	0.18	0.007	0.17-0.20	3.86

Oliva bulowi phuketensis (adults).

Teleoconch data. N = 16.						
	min val.	max val.	mean val.	st. dev.	95% prob. range	% var.
L/pnw	3.79	5.28	4.50	0.406	3.69-5.31	9.03
H/L	1.29	1.39	1.36	0.025	1.31-1.41	1.83
LW/L	1.10	1.17	1.14	0.019	1.10-1.18	1.65
D/L	0.57	0.67	0.63	0.026	0.57-0.68	4.14
R/L	0.35	0.42	0.38	0.022	0.34-0.43	5.66
X/L	0.46	0.55	0.51	0.023	0.46-0.55	4.64
(X-R)/L	0.10	0.15	0.12	0.013	0.10-0.15	10.43
(H-L)/L	0.29	0.39	0.36	0.025	0.31-0.41	6.97
100 (sut/L)	1.74	2.62	2.10	0.209	1.68-2.51	9.99
F/L	0.44	0.51	0.46	0.019	0.42-0.50	4.14

(values non rounded).

5.2.2. Colour pattern. Similar to that of *O.bulowi bulowi* but generally lacking the prominent oblique, dark flammulations. The body whorl is decorated with dark triangular marking reminiscent of those found in *O.amethystina* Röding. There is a strong tendency to the retention of "panther" type juvenile pattern in adults.

5.2.3. Distribution. This subspecies is known so far only from Phuket (South West Thailand) and the Andaman Islands.

5.2.4. Status. The reasons for considering this phenon as a subspecies have been discussed in section 4.1.

5.2.5. Differences.

The most reliable difference between *Oliva bulowi* and *Oliva bulowi phuketensis* are in the protoconch characters and are reported hereunder.

	min val.	max val.	mean val.	st. dev.	95 % prob. range
RES5					
<i>bulowi</i>	1.42	1.69	1.53	0.063	1.41-1.66
<i>bulowi phuketensis</i>	1.64	1.90	1.76	0.079	1.60-1.92
RES4/nw					
<i>bulowi</i>	0.24	0.28	0.26	0.012	0.23-0.28
<i>bulowi phuketensis</i>	0.28	0.33	0.31	0.019	0.27-0.35

The protoconchs are actually very similar in aspect, that of *O.bulowi phuketensis* appearing larger only because it has a larger nw.

5.2.6. Type specimens.

HOLOTYPE : (Pl. 1 fig. 1) H:30.7 mm, deposited in the type collection of the Institut Royal des Sciences Naturelles de Belgique under the number 426.

Paratype 1: (Pl.1, fig. 5) H:28.8 mm, British Museum (Natural History), n° 1953.3.9.(4).

Paratype 2: (Pl.1, fig. 2) H:29.9 mm, BT-1560, in the collection of B.Tursch.

Paratype 3: (Pl.1, fig. 3) H:31.4 mm, BT-1565, in the collection of B.Tursch.

Paratype 4: (Pl.1, fig. 4) h:31.4 mm, BT-1565, in the collection of D.Greifeneder.

5.2.7. Type locality: Phuket, Thailand.

6. ACKNOWLEDGEMENTS.

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7. MATERIAL EXAMINED.

Counts and measurements have been effected on the material listed hereunder. BMNH refers to specimens from the British Museum (Natural History), DG to the Dietmar Greifeneder collection, BT to the Bernard Tursch collection. All 74 measured specimens had an intact protoconch. In addition to the list hereunder, many more specimens have been inspected in museums, private collections and dealer stocks.

7.1. *Oliva bulowi* Sowerby, 1888 (typical, adults).

PAPUA NEW GUINEA, Hansa Bay, 10 specimens: BT-0416, BT-0419 to BT-0426, BT-4697.

PAPUA NEW GUINEA, New Britain, 10 specimens: BT-0399, BT-0401 to BT-0403, BT-0405, DG-NL, DG-N15, DG-3943/1 and /2, DG-4724.

PAPUA NEW GUINEA, Port Moresby, 5 specimens: DG-N2, DG-4477, DG-4478, DG-4478/1 and /2.

SOLOMON Islands, Guadalcanal, 10 specimens: BT-4434, BT-4436, DG-4300/1 to DG-4300/8.

7.2. *Oliva bulowi* Sowerby, 1888 (typical, juveniles).

PAPUA NEW GUINEA, Hansa Bay, 6 specimens: BT-0411 to BT-0414 and BT-0417 to BT-0418.

7.3. *Oliva bulowi* Sowerby, 1888 ("X" shells, "panther" pattern)

PAPUA NEW GUINEA, Hansa Bay, 8 specimens: BT-0406 to BT-0410, BT-1558, BT-4698, DG-5896.

PAPUA NEW GUINEA, Port Moresby, 8 specimens: DG-N8, DG-N14a, DG-N14b, DG-4891/1 to DG-4891/5.

7.4. *Oliva bulowi phuketensis*.

ANDAMAN Islands, Port Blair, 9 specimens: BMNH-1953.3.9/1 to BMNH-1953.3.9/9.

THAILAND, Phuket, 8 specimens: BT-1559 to BT-1566.

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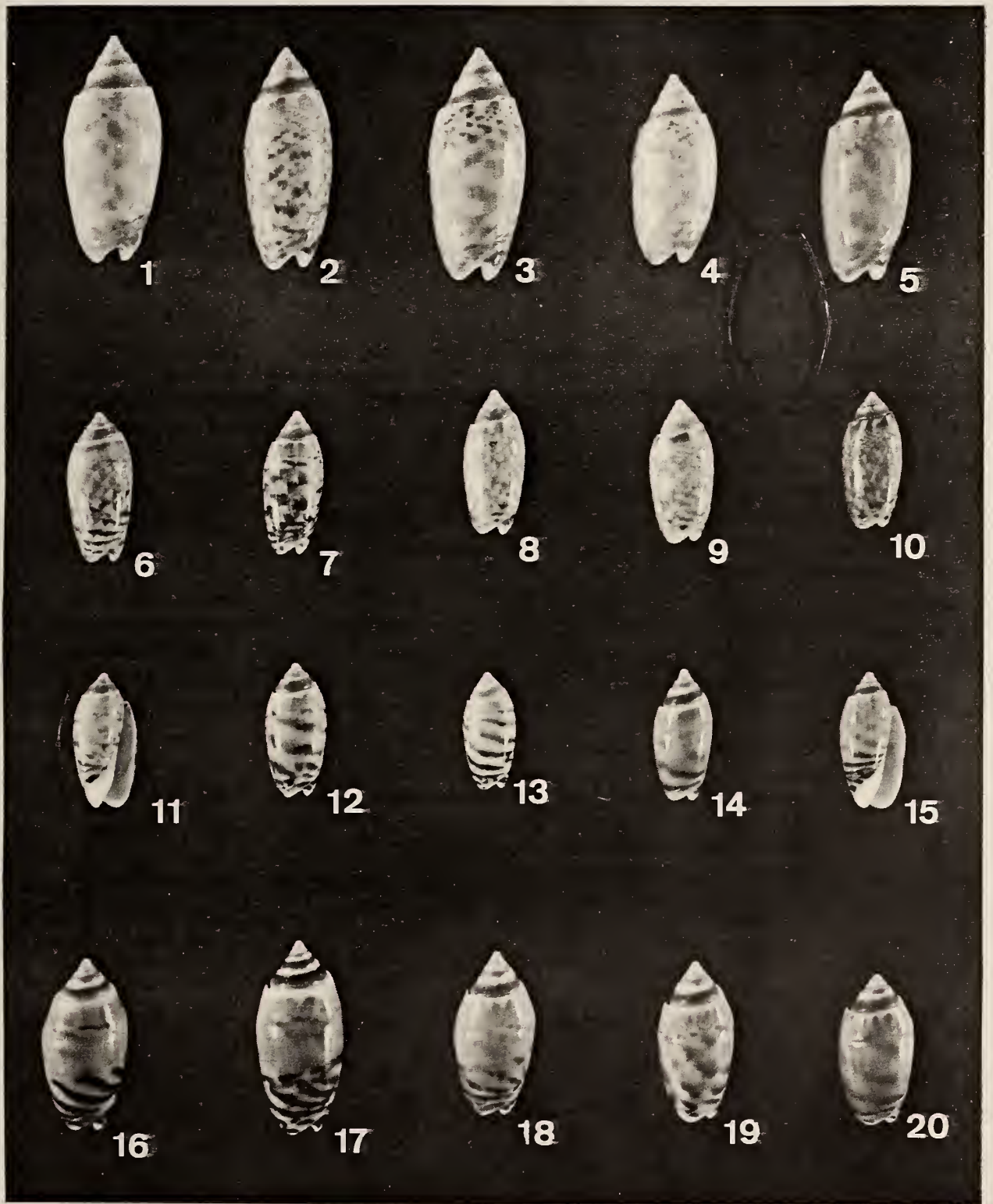


Plate 1

Plate 1.

1. *O. bulowi phuketensis*, n. subsp. Specimen BT-1566. H: 30.7 mm.
Thailand, Phuket. HOLOTYPE,
2. *O. bulowi phuketensis*, n. subsp. Specimen BT-1560. H: 29.9 mm.
Thailand, Phuket. PARATYPE 2.
3. *O. bulowi phuketensis*, n. subsp. Specimen BT-1559. H: 31.4 mm.
Thailand, Phuket. PARATYPE 3.
4. *O. bulowi phuketensis*, n. subsp. Specimen BT-1565. H: 25.9 mm.
Thailand, Phuket. PARATYPE 4.
5. *O. bulowi phuketensis*, n. subsp. Specimen BMNH-1953.3.9.(4). H: 28.8 mm.
Andaman Islands, Port Blair. PARATYPE 1.
6. *O. bulowi* Sowerby 1888. Specimen BT-1558. H: 20.4 mm.
Papua New Guinea, Laing Island, dredged 20-35 m.
7. *O. bulowi* Sowerby 1888. Specimen BT-0408. H: 19.7 mm.
Papua New Guinea, Laing Island, dredged 20-35 m.
8. *O. bulowi* Sowerby 1888. Specimen DG-4891/3. H: 19.6 mm.
Papua New Guinea, Port Moresby, Lion Island, 20-23 m.
9. *O. bulowi* Sowerby 1888. Specimen DG-4891/2. H: 19.6 mm.
Papua New Guinea, Port Moresby, Lion Island, 20-23 m.
10. *O. bulowi* Sowerby 1888. Specimen DG-4891/5. H: 18.7 mm.
Papua New Guinea, Port Moresby, Lion Island, 20-23 m.
11. *O. bulowi* Sowerby 1888. THIS IS THE SAME SPECIMEN as fig. 12. BT-0417. H: 18.4 mm.
Papua New Guinea, Laing Island, dredged 35-60 m.
12. *O. bulowi* Sowerby 1888. THIS IS THE SAME SPECIMEN as fig. 11. BT-0417. H: 18.4 mm.
Papua New Guinea, Laing Island, dredged 35-60 m.
13. *O. bulowi* Sowerby 1888. Specimen BT-0411. H: 16.2 mm.
Papua New Guinea, Laing Island, dredged 35-60 m.
14. *O. bulowi* Sowerby 1888. Specimen BT-0414. H: 18.0 mm.
Papua New Guinea, Laing Island, dredged 35-60 m.
15. *O. bulowi* Sowerby 1888. Specimen BT-0415. H: 18.7 mm.
Papua New Guinea, Laing Island, dredged 35-60 m.
16. *O. bulowi* Sowerby 1888. Specimen BT-0401. H: 23.5 mm.
Papua New Guinea, New Britain, Rabaul, 40 m.
17. *O. bulowi* Sowerby 1888. Specimen BT-0422. H: 18.4 mm.
Papua New Guinea, Laing Island, dredged 40-55 m.
18. *O. bulowi* Sowerby 1888. Specimen BT-0420. H: 22.8 mm.
Papua New Guinea, Laing Island, dredged 35-60 m.
19. *O. bulowi* Sowerby 1888. Specimen BT-4433. H: 22.5 mm.
Solomon Islands, Guadalcanal, 18 m.
20. *O. bulowi* Sowerby 1888. Specimen DG-4300/2. H: 18.4 mm.
Solomon Islands, Marau Sound.

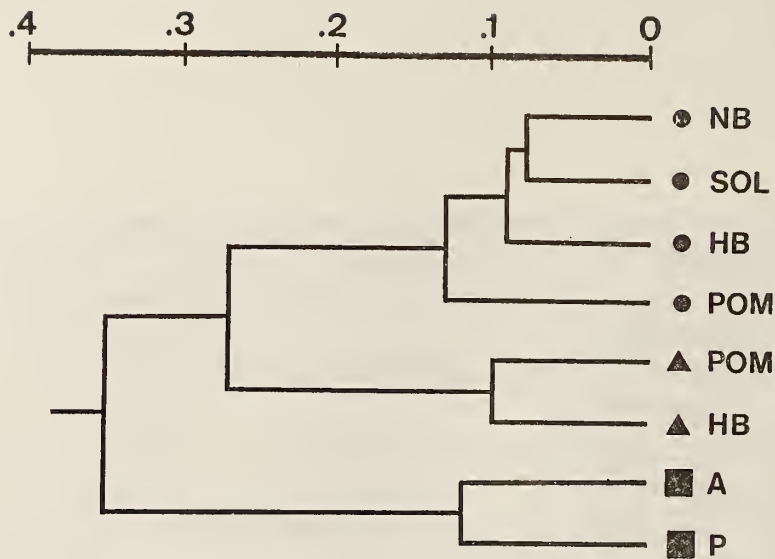


Fig. 2.

Phenogram obtained by UPGMA clustering of the euclidian distance matrix of centroids, obtained on the 30 characters of list A (section 2.3). Black squares are adult *O.bulowi phuketensis*, black circles typical adult melanesian *O.bulowi* ("tiger" pattern), black triangles "X" shells ("panther" pattern). A stands from Andaman Islands, HB stands for PNG-Hansa Bay, NB for PNG-New Britain, P for Thailand-Phuket, POM for PNG-Port Moresby, SOL for Solomon Islands. NO JUVENILES.

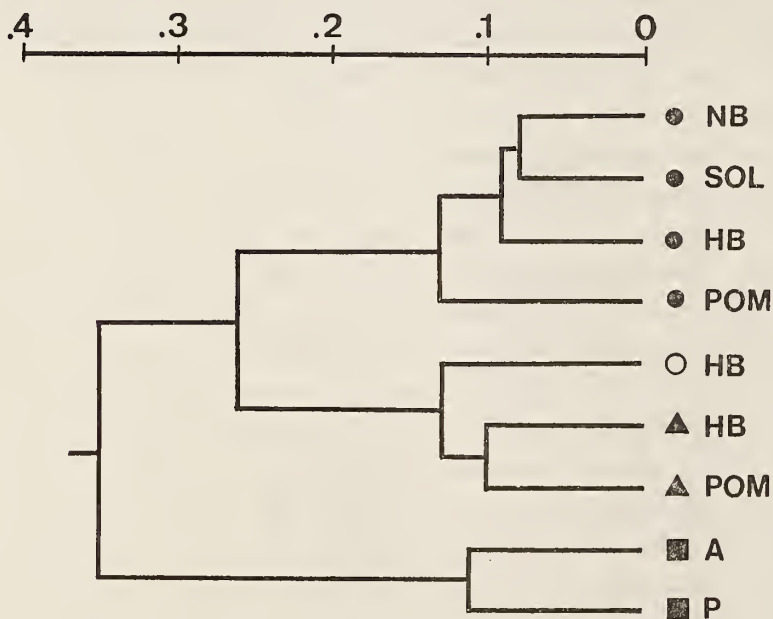


Fig. 3.

Phenogram obtained by UPGMA clustering of the euclidian distance matrix of centroids, obtained on the 30 characters of list A (section 2.3). Black squares are adult *O.bulowi phuketensis*, black circles typical adult melanesian *O.bulowi* ("tiger" pattern), open circles typical juvenile melanesian *O.bulowi* ("tiger" pattern) and black triangles "X" shells ("panther" pattern). A stands for Andaman Islands, HB stands for PNG-Hansa Bay, NB for PNG-New Britain, P for Thailand-Phuket POM for PNG-Port Moresby, SOL for Solomon Islands. JUVENILES INCLUDED.

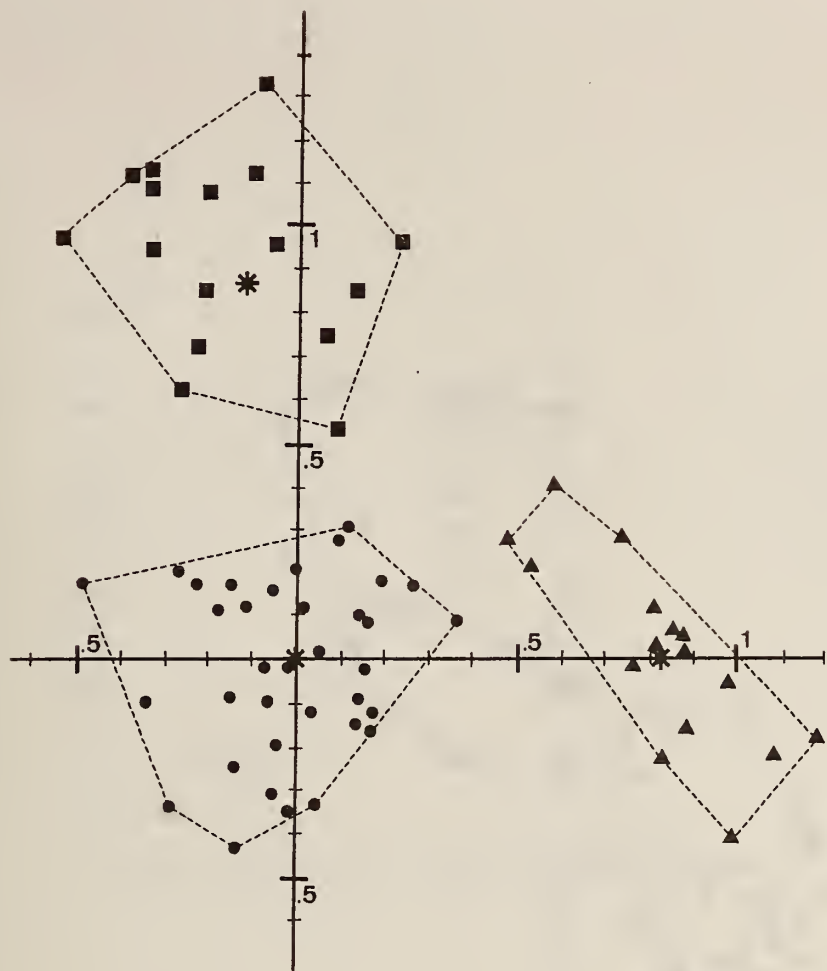


Fig. 4.

TAXSEE projection.
 Black squares are adult *O. bulowi phuketensis*, black circles typical adult melanesian *O. bulowi* ("tiger" pattern), and black triangles "X" shells ("panther" pattern). Stars represent centroids of each group.

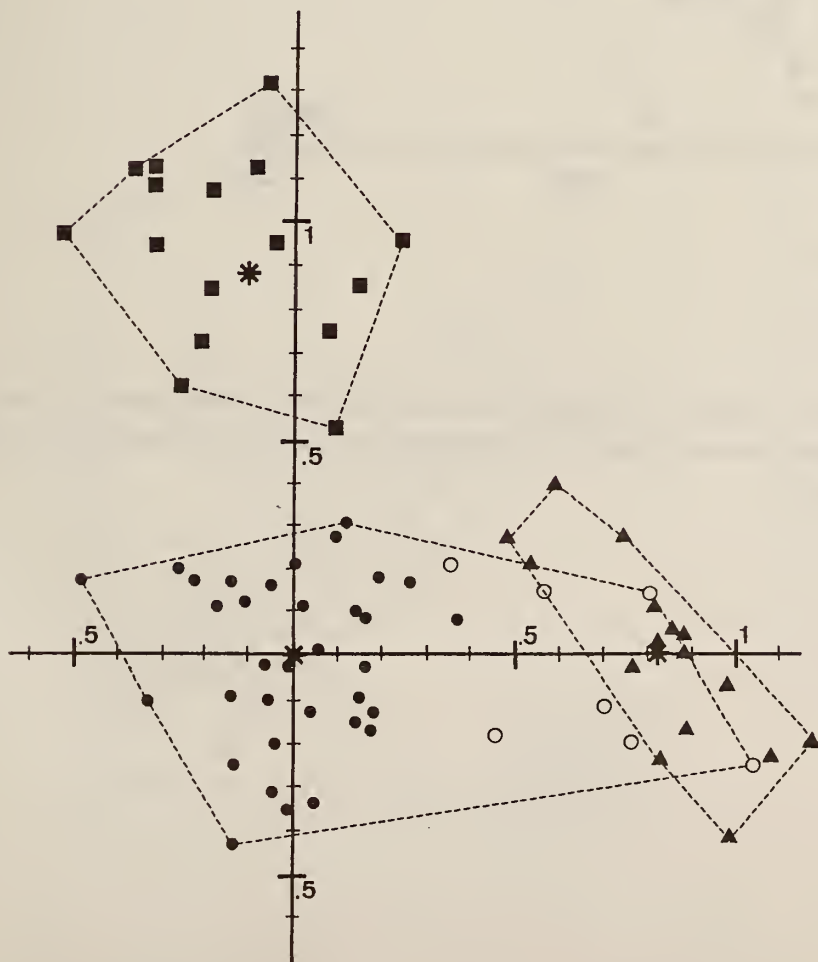


Fig. 5.

TAXSEE projection.
 Black squares are adult *O. bulowi phuketensis*, black circles typical adult melanesian *O. bulowi* ("tiger" pattern), open circles typical juvenile melanesian *O. bulowi* ("tiger" pattern) and black triangles "X" shells ("panther" pattern). Stars represent centroids of each group.

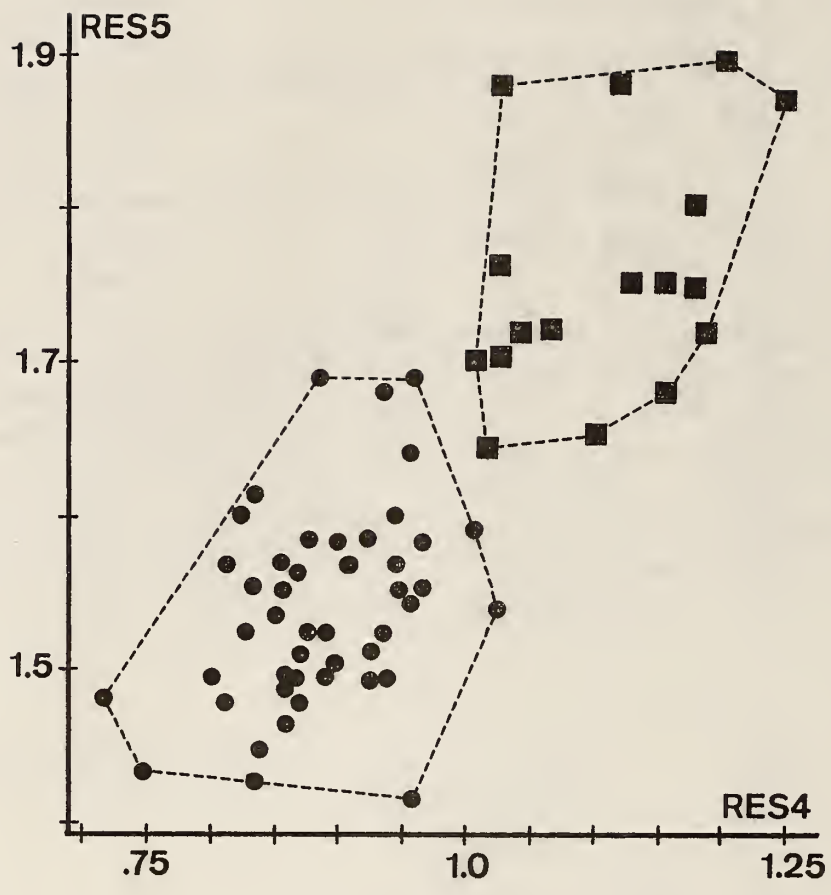


Fig. 6.

Scatter diagram of RES4 vs RES5. Minimum convex polygons. Black squares are adult *Oliva bulowi phuketensis*, black circles typical adult melanesian *Oliva bulowi* ("tiger" pattern).

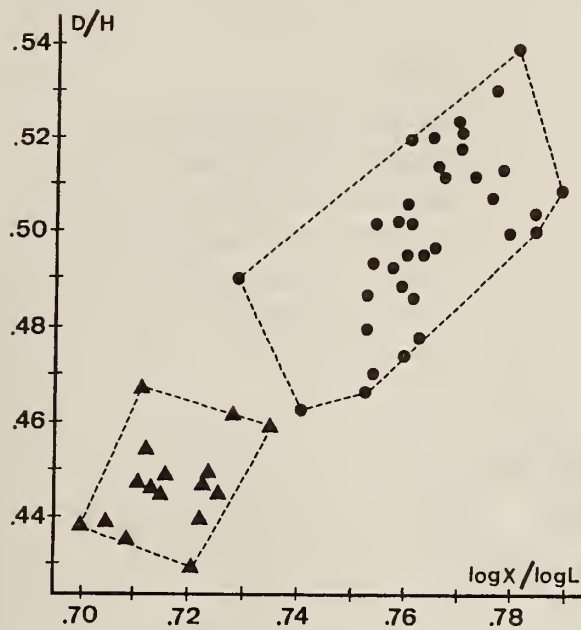


Fig. 7.

Scatter diagram of $\log.X/\log.L$ vs. D/H . Minimum convex polygons. Black circles are typical adult melanesian *O.bulowi* ("tiger" pattern) and black triangles "X" shells ("panther" pattern).

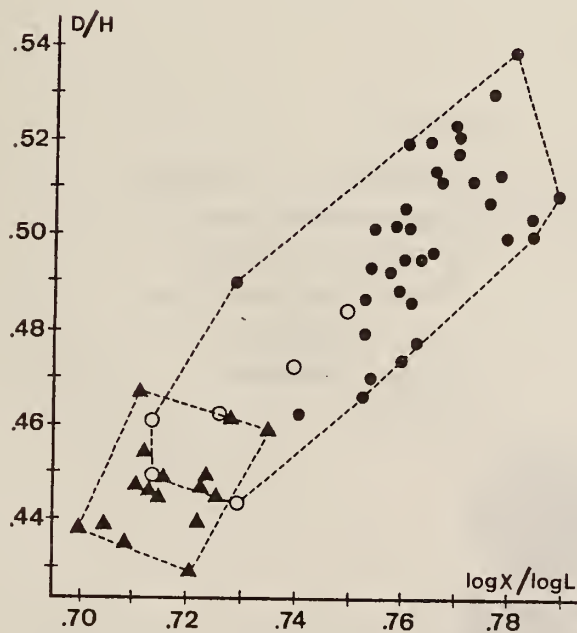


Fig. 8.

Scatter diagram of $\log.X/\log.L$ vs. D/H . Minimum convex polygons. Black circles are typical adult melanesian *O.bulowi* ("tiger" pattern), open circles typical juvenile melanesian *O.bulowi* ("tiger" pattern) and black triangles "X" shells ("panther" pattern).